

Genetic analysis for multiple fruit yield and its attributing traits in eggplant (*Solanum melongena* L.) used as wild species *Solanum gilo* as male parent under tarai conditions of Uttarakhand

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Abstract

The identification of heterotic combinations may provide a significant benefit in hybrid eggplant / brinjal (*Solanum melongena* L.) breeding. This two year study evaluated the gene action and combining effects that governs yield and yield contributing characters in brinjal. A set of 28 F₁ hybrids were generated by crossing eight parents, the crosses PB-6 x PB-101, BARI x Pusa Upkar, Pant Rituraj x Pusa Upkar, SMB-115 x Pant Rituraj, Pant Rituraj x PB-101, Pusa Upkar x PB-101 exhibited high sca effect for majority of the characters under study. On the basis of these ranking best parents and best specific combination could be identified for further breeding programme for brinjal improvement. The magnitudes of specific combining ability variance were higher than general combining ability variance for all characters in both years 2018 & 2019. This indicated that the physiological and vegetable characters were predominantly under the non-additive control whereas, additive genetic control was observed to be predominant for yield per hectare. Further it was also observed that the degree of dominance was found to be more than unity for all characters in both years, indicating over dominance types of gene action for these characters. Predominance of non-additive genetic variance indicated the suitability of heterosis breeding for improvement of this trait in eggplant. These crosses could be utilized and the prospect of extracting transgressive segregants in the segregating generations.

Introduction

Vegetable demand is rising globally, and this trend is projected to continue in the future (Godfray et al. 2010). Vegetables, which are well suited to crop rotation, high in nutrients and minerals, and diversified in character, can contribute effectively to addressing food security concerns (Bisbis et al. 2018). The eggplant or brinjal (*Solanum melongena* L.), one of the most popular and widely grown vegetables in India, belonging to the genus *Solanum*, is among the largest genera, having more than 1500 described plant species (Chen 1998). In Europe, the vegetable is known as "aubergine," while in Southeast Asia, South Asia, and Africa, it is known as "brinjal." In Asia and the Mediterranean, eggplant, also known as brinjal, is one of the top five vegetable crops (Taher et al. 2017). Immature fruit of cultivated species of eggplant are commonly used as a summer vegetable. Vavilov (1928) was of the opinion of Indo-Burma as its center of origin however, the greatest diversity in its wild relatives is found in Africa (Knapp et al. 2013). Eggplant is a warm-season crop that is perennial in nature but also produced as an annual crop, is a versatile crop since it is a hardy plant with a wide range of adaptation. It is possible to grow the crop all through the year, with relatively little work and expense of cultivation. Wild eggplant cousins are a one-of-a-kind source of improvement for critical qualities including insect and disease resistance, drought tolerance, and quality attributes like a high concentration of bioactive phenolic acids (Gramazio et al. 2018). Eggplant contains a variety of therapeutic characteristics that are used to treat diabetes, asthma, cholera, bronchitis, and diarrhoea (Mennella and colleagues 2012) and bitterness is due to the presence of saponins and glycoalkaloids (Mariola et al. 2013). Combining ability analysis aids in the identification of parents with high gca and parental combinations with high sca. (Kaushik et al., 2018). The consequences of general combining ability play a big role in deciding which parents to be used and isolating germplasm

to use in a hybridization programme for future enhancement. In general, eggplant breeding projects attempt to create high-yielding cultivars, usually F_1 hybrids, with good fruit quality, shelf life, and resistance to major disease and insect pests, as well as a wide range of environmental stress tolerance (Daunay and Hazra 2012). To proceed with an effective genetic improvement of plants, information on the inheritance of crucial features and their gene function is required. Combining ability refers to a genotype's capacity to pass on better traits to its offspring. The average performance of a line in a series of hybrid combinations is known as general combining ability (GCA), whereas specific combining ability (SCA) refers to the effects in some specific combinations that deviated significantly from what would be expected based on the average performance of the lines involved Sprague and Tatum (1942). Furthermore, hybrids must be used for economic purposes by selecting parents from germplasm from time to time and at various places and seasons. In the construction of an effective breeding programme, information on combining ability and the forms of gene action that determines the transmission of economically relevant quantitative features is extremely valuable. It not only aids in the identification of parents and crosses that are most likely to enhance the characteristics in question, but it also aids in the study of the genetic architecture of metric traits.

Material And Methods

The study was conducted during the rainy (*kharif*, June-December) season of 2018 and 2019 at Vegetable Research Center, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand, India. The climate of the area is comprehensively sub-tropical and the temperature ranges from 32°C to 40°C during summer months. Relative humidity is just about 80–90 per cent from mid-June to end of February (Fig. 1). The soil of field at Vegetable Research Center was deep, fertile and sandy loam which is suitable for early crop and had pH of 7.2 which is also good for growth and development of plant. The experimental material in present investigation consisted of eight genotypes of eggplant namely SMB-115, BARI, Pant Samrat, Pant Rituraj, PB-6, Pusa Upkar, PB-101 and *S. gilo* and these genotypes used in the present investigation were collected from different sources. (Supplementary Table.1) The fertilizers were applied as N: P: K @ 120: 60: 60 Kg/ ha. Half dose of nitrogen with full phosphorus and potassium were applied as basal dose and half of the nitrogen was applied as top dressing in two split doses i.e., 30–35 days and 60–65 days after transplanting. Immediately after transplanting, the field was irrigated and general agronomic practices were followed to raise a good crop. For both years, an analysis of variance of combining ability was conducted independently for all fifteen characters, and the findings are reported in Table 1. The mean squares were divided into three categories as: gca, sca, and error mean squares. In both the years 2018 and 2019, the general combining ability (gca) mean squares were found extremely significant for all of the characters under study.

Results

The days to first flowering of a particular genotype is an indicator of earliness which is highly desirable trait. Among the parents, the estimates ranged from -0.98 to 8.52. In first year, where three parents viz.,

PB-6(-3.66) Pant Rituraj (-2.78) and BARI (-2.75) were in desired negative direction. In the second year, six parents exhibited significant effect, ranging from 0.54 to 8.70. Again, above three parents showed negative effect PB-6 (-3.94), Pant Rituraj (-3.30) and BARI (-2.49) which indicated that the parents are good combiners for early maturity. The estimates of gca effects indicated that BARI, Pant Rituraj and PB-6 were the good combiners for days to first flowering, high gca and high per se performance in these genotypes indicated that days to first flowering in these lines was governed by additive gene effects. As a result, these parents might be chosen to encourage early maturity. Conformity results were also reported by (Godfray et al. 2010; Meyer et al. 2012). These findings are comparable and similar to those of (Knapp et al. 2013). For number of marketable fruits per plant in the first year, seven parents exhibited significant estimates of gca, ranged from -7.14 to 2.77, whereas five parents namely Pant Samrat (2.77) PB-101(1.33) SMB-115 (0.80) and BARI (0.77) were in desired positive direction. Similar results were observed in the second year. Thus, Pant Samrat (3.43) and PB-101 (1.24) were best general combiners for the trait, which showed significant estimates in desired positive direction in the both years. This result, is similar to the reported by (Bhushan et al. 2012; Deshmukh et al. 2015; Mistry et al. 2016). As, regard with the number of unmarketable fruits per plant six parents showed significant effect in the first year, whereas two parents in desired negative direction Pant Samrat (-0.40) and *S. gilo* (-3.28). Similar results were observed in the second year where same parents namely Pant Samrat (-0.22) and (-3.25) showed significant estimates with negative significant estimates. BARI, Pant Rituraj, PB-6, and PB-101 showed consistent results in positive direction and two parents *S. gilo* and Pant Samrat in negative desired direction. Thus, Pant Samrat and *S. gilo* were best general combiners for this trait number of unmarketable fruits per plant. This result, is similar as reported by Sao and Mehta 2010. For the trait of total number of fruits per plant seven parents showed gca effects in the first year, ranged from -10.21 to 2.34, whereas seven parents Pant Samrat (2.34), BARI (2.21), PB-101 (1.85), Pant Rituraj (1.48) and SMB-115 (1.38) were in desired direction. In the second year similarly seven parents SMB-115, BARI, Pant Samrat, Pant Rituraj, PB-6, Pusa Upkar and PB-101 were in desired direction, where only one parents *S. gilo* was in negative direction. SMB-115, BARI, Pant Samrat and PB-101 high significant gca effect. Thus, superior parents for this trait were BARI, SMB-115, Pant Samrat and PB-101 which showed significantly positive gca effects in both the years. This result is in agreement with the findings of Mistry et al. 2016. Yield is one of the most important traits for improvement of eggplant. The general combining ability for this trait is very much important for improvement of eggplant genotypes. In the first year, six parents showed highly significant estimates for total yield per plant (kg) ranged from -1.24 to 0.68 whereas, PB-101 (0.68) Pant Rituraj (0.41), SMB-115(0.15) and PB-6 (0.10) were in desired positive direction. In the second year eight parents exhibited significant gca estimates effects, ranging from -1.33 to 0.71 whereas, PB-101 (0.71), Pant Rituraj (0.49), SMB-115(0.26), Pusa Upkar (0.23) and Pant Samrat (0.06) were in desired positive direction. Thus, for total yield per plant SMB-115, Pant Rituraj and PB-101 were established as good general combiners, which showed consistent positive gca effects in both years. This result was in agreement with the findings of Reddy and Patel 2014 ; Deshmukh et al. 2015. Yield per hectare is the most important trait which determines the worthiness of a genotype. In the first year, eight parents showed highly significant estimates for yield per hectare (q) ranged from -282.55 to 135.76 whereas PB-101 (135.76), Pant Rituraj (105.79), PB-6 (32.06) and SMB-115(26.09) were in desired

positively direction. In the second year eight parents exhibited significant gca estimates effects, ranged from -309.98 to 129.52 whereas, Pant Rituraj (129.52) PB-101 (129.03) and SMB-115(44.10) were in desired positive direction. Thus, for yield per hectare (q) SMB-115, Pant Rituraj and Pusa Upkar were established as good general combiners, which showed consistent positive gca effects in both years. Similar results were reported by Sao and Mehta 2010. For number of marketable fruits per plant, twenty-six crosses exhibited significant sca estimates and ranged from -10.40 to 12.59 in the first year. The highest positive significant sca effects estimates were found in the crosses BARI x Pant Samrat (12.59), PB-6 x PB-101 (6.18) BARI x Pusa Upkar (5.16), SMB-115 x BARI (3.12), Pant Rituraj x Pusa Upkar (3.00), PB-6 x Pusa Upkar (2.68), BARI x PB-101 (2.35) and Pant Rituraj x PB-101(2.23). In the second year, twenty-five crosses showed exhibited high significant sca effects ranged from -11.14 to 12.66. BARI x Pant Samrat (12.66), PB-101 x PB-6 (6.79), BARI x Pusa Upkar (4.76), Pant Rituraj x PB-101 (3.24), SMB-115 x BARI (2.71) and Pant Rituraj x PB- 6 (2.71) exhibited desired direction. Thus, crosses showed consistent positive sca effects over both the years were namely BARI x Pant Samrat, BARI x Pusa Upkar PB-101 x PB-6 and PB-6 x PB-101. Similar results were reported by (Sao and Mehta 2010; Mistry et al. 2016). For number of unmarketable fruits per plant, twenty seven crosses exhibited significant sca estimates in the first year, ranged from -2.04 to 4.46. Where twelve crosses showed negative values i.e., BARI x Pusa Upkar (-2.45), BARI x *S. gilo* (-2.04), BARI x Pant Rituraj (-1.89), Pant Rituraj x *S. gilo* (-1.75) Pant Rituraj x PB-6 (-1.63), Pant Rituraj x PB-101 (-1.51), Pant Samrat x Pusa Upkar (-1.45), SMB-115 x *S. gilo* (-1.25), SMB-115 x Pusa Upkar (-1.19), SMB-115 x PB-101 (-1.11) and PB-101 x *S. gilo* (-1.09). In the second year, twenty four crosses exhibited highest significant sca effects and ranged from -2.04 to 4.63. The crosses BARI x *S. gilo* (-2.04), BARI x Pusa Upkar (-1.94), SMB-115 x Pusa Upkar (-1.80), Pant Rituraj x *S. gilo* (-1.76), Pant Samrat x Pusa Upkar (-1.51), Pant Rituraj x PB-101 (-1.40), SMB-115 x PB-101(-1.33), SMB-115 x *S.gilo* (-1.23), BARI x Pant Rituraj (-1.21) and SMB-115 x Pant Rituraj (-1.17) showed desired estimates. Thus crosses viz., SMB-115 x Pusa Upkar, SMB-115 x PB-101, BARI x Pusa Upkar, Pant Samrat x Pusa Upkar and Pant Rituraj x PB-101 showed consistent values over both the years in negative direction. Sao and Mehta (2010) also reported similar effects in different crosses of brinjal for number of the unmarketable fruits per plant. For total number of fruits per plant, twenty-four crosses exhibited significant sca estimates in the first year and ranged from -10.56 to 13.33. The crosses BARI x Pant Samrat (13.33), PB-6 x PB-101 (6.29), Pusa Upkar x PB-101 (6.23), Pant Rituraj x Pusa Upkar (4.47), BARI x PB-101 (3.72), BARI x Pusa Upkar (2.65), PB-6 x Pusa Upkar (2.20) and BARI x PB-6 (2.17) showed desired estimates. In the second year, twenty-four crosses showed highest significant sca effects and ranged from -11.10 to 13.12. The crosses BARI x Pant Samrat (13.12), Pusa Upkar x PB-101 (6.84), PB-6 x PB-101 (5.64), Pant Rituraj x Pusa Upkar (4.45), BARI x PB-101 (3.95), BARI x PB-6 (2.77), BARI x Pusa Upkar (2.30), and Pant Rituraj x PB-101 (2.00) showed values in positive direction. Thus, these crosses, BARI x Pant Samrat, PB-6 x PB-101 and Pusa Upkar x PB-101 established as good specific combinations for total number of fruits per plant (Thangravel et al., 2011). For weight marketable fruits per plant twenty-five crosses exhibited significant estimates in the first year, ranged from -1.07 to 1.05, where twelve crosses showed positive values. The maximum values of sca estimates showed in the crosses by SMB-115 x Pant Rituraj (1.05), PB-6 x Pusa Upkar (0.88), BARI x Pant Samrat (0.71), Pant Rituraj x Pusa Upkar (0.66), PB-6 x PB-101 (0.58), BARI x PB-101 (0.48) and BARI x Pusa Upkar (0.44) in positive

direction. In the second year, twenty five crosses showed highest significant sca effects ranged from -1.02 to 0.87 were as ten crosses exhibited maximum values of sca estimates namely, SMB-115 x Pant Rituraj (0.87), BARI x Pant Samrat (0.66), PB-6 x Pusa Upkar (0.56), Pant Rituraj x PB-101 (0.50), BARI x PB-101 (0.46), BARI x Pant Rituraj (0.44), BARI x Pusa Upkar (0.42), PB-6 x PB-101 (0.38) and Pant Samrat x Pant Rituraj (0.31) in positive direction. Hence, these crosses established as good specific combinations for this trait SMB-115 x Pant Rituraj, BARI x Pant Samrat, BARI x Pusa Upkar, BARI x PB-101, PB-6 x Pusa Upkar and PB-6 x PB-101 for both the years. Similar results were reported by(Sane et al. 2011 ; Khapte et al. 2013). For total yield per plant in the first year, six crosses exhibited significant sca effects ranged from -1.25 to 1.43 where, three crosses showed positive values. The highest positive value shown in the cross, BARI x Pusa Upkar (1.43) and PB-6 x PB-101 (1.35) and SMB-115 x Pant Rituraj (1.21). In the second year, only one cross showed positive significant sca effects and the estimates ranged from -1.35 to 1.11. Hence, SMB-115 x Pant Rituraj (1.11) proved as good specific combiner for total yield per plant (Mistry et al., 2016). For yield per hectare twenty four crosses exhibited crosses exhibited significant sca effects in the first year, ranged from -350.35 to 373.47, where eleven showed positive values but maximum estimates observed in the crosses, PB-6 x Pusa Upkar (373.47), BARI x Pant Samrat (237.42), SMB-115 x Pant Rituraj (185.04), BARI x Pusa Upkar (129.21), SMB-115 x Pant Samrat (190.46), Pant Rituraj x Pusa Upkar (161.09) and BARI x PB-101 (124.38). In the second year, values ranged from -369.51 to 384.43, eleven crosses showed significant positive values i.e., PB101 x PB-6 (384.43), BARI x Pant Samrat (264.87), SMB-115 x Pant Rituraj (216.91), Pant Rituraj x PB-101 (208.38), BARI x Pusa Upkar (178.58), SMB-115 x Pant Samrat (159.33) and BARI x PB-101 (120.08). Thus, these crosses *viz.*, SMB-115 x Pant Samrat, PB101 x PB-6, SMB-115 x Pant Rituraj, BARI x Pusa Upkar and BARI x PB-101 gave consistent significant sca estimates over both the years .Similar study was reported by Darrah and Hallauer 1972; Bhushan et al., (2012). The estimates of variance due to general combining ability specific combining ability, additive variance dominant variance, and heritability in narrow sense, heritability in broad sense, gca/sca ratio and degree of dominance for various characters are given in Table.7 for first year and in Table.8 for second year respectively. It is evident from the result that in general, the magnitudes of specific combining ability variance were higher than general combining ability variance for all characters in both years. This indicated the physiological and vegetable characters were predominantly under the non-additive control whereas, additive genetic control was observed to be predominant for yield per hectare (q). Further it was also observed that the degree of dominance was more than unity for all most of characters in both years, which indicated over dominance types of gene action for these characters. Predominance of non-additive genetic variance indicated the suitability of heterosis breeding for improvement of this trait in brinjal (Darrah and Hallauer 1972).

Table 2: Estimates of gca for fifteen characters of eggplant for the year 2018

Parents	Days to first flowering	Number of marketable fruits per plant	Number of un marketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare(q)
SMB-115	1.52**	0.80**	0.61**	1.38**	0.15**	26.09**
BARI	-2.75**	0.77**	1.40**	2.21**	-0.05*	-29.28**
Pant Samrat	0.68	2.77**	-0.40**	2.34**	-0.04	4.41**
Pant Rituraj	-2.78**	0.32	1.11**	1.48**	0.41**	105.79**
PB-6	-3.66**	0.18	0.03	0.28	0.10**	32.06**
Pusa Upkar	8.52**	0.96**	0.07	0.67*	0.00	7.72**
PB101	-0.56	1.33**	0.45**	1.85**	0.68**	135.76**
<i>S. gilo</i>	-0.98	-7.14**	-3.28**	-10.21**	-1.24**	-282.55**
S.E. (gi)	0.587	0.156	0.037	0.184	0.019	3.764
S.E. (gi-gj)	0.886	0.733	0.056	0.881	0.028	5.691

*,**: Significant at 0.05 and 0.01 probability level, respectively.

Table 3: Estimates of gca for fifteen characters of eggplant for the year 2019

Parents	Days to first flowering	Number of marketable fruits per plant	Number of un marketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare(q)
SMB-115	2.32**	0.91**	0.50**	1.42**	0.26**	44.10**
BARI	-2.49**	0.34	1.30**	2.18**	-0.22**	-32.35**
Pant Samrat	0.03	3.43**	-0.22**	2.80**	0.06*	7.66
Pant Rituraj	-3.30**	0.30	1.03**	1.28**	0.49**	129.52**
PB-6	-3.94**	0.31	0.12*	0.72**	-0.19**	32.62**
Pusa Upkar	8.70**	0.75**	-0.01	0.68*	0.23**	-0.60
PB101	-0.77	1.24**	0.52**	1.63**	0.71**	129.03**
<i>S. gilo</i>	-0.54	-7.28**	-3.25**	-10.70**	-1.33**	-309.98**
S.E. (gi)	0.610	0.171	0.037	0.201	0.019	4.307
S.E. (gi-gj)	0.923	0.258	0.057	0.304	0.029	6.512

Table 4: Estimates of sca for fifteen characters of eggplant for the year 2018

Crosses	Days to first flowering	Number of marketable fruits per plant	Number of unmarketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare(q)
SMB-115 x BARI	14.07**	3.12**	-0.72**	2.49**	-1.14*	-166.78**
SMB-115 x Pant Samrat	12.97**	-5.54**	2.97**	-2.44**	1.04	190.46**
SMB-115 x Pant Rituraj	1.10	-2.30**	-0.37*	-2.81**	1.21*	185.04**
SMB-115 x PB-6	2.98	-0.60	-0.39*	0.23	-1.24*	-267.92**
SMB-115 x Pusa Upkar	-15.87**	0.89*	-1.19**	-2.33**	-0.17	-27.09*
SMB-115 x PB-101	9.55**	-0.41	-1.11**	-1.21	-0.52	-67.73**
SMB-115 x <i>S. gilo</i>	0.96	-8.43**	-1.25**	-9.61**	-0.40	-85.15**
BARI x Pant Samrat	-9.84**	12.59**	0.41*	13.33**	0.75	237.42**
BARI x Pant Rituraj	0.70	-4.04**	-1.89**	-5.67**	0.25	-13.24
BARI x PB-6	19.25**	1.53**	0.99**	2.17**	0.07	17.62
BARI x Pusa Upkar	-15.26**	5.16**	-2.45**	2.65**	0.41	129.21**
BARI x PB-101	-13.18**	2.35**	1.67**	3.72**	1.43**	124.38**
BARI x <i>S. gilo</i>	5.57**	-8.40**	-2.04**	-10.45**	-0.20	-29.78*
Pant Samrat x Pant Rituraj	-6.73**	-5.00**	0.47**	-4.16**	-0.50	-0.29
Pant Samrat x	-2.85	-2.13**	-0.26*	-3.12**	0.19	85.17**

PB-6						
Pant Samrat x Pusa Upkar	-0.03	-1.70**	-1.45**	-3.16**	-1.25*	-210.49**
Pant Samrat x PB-101	12.39**	-3.67**	0.36**	-3.84**	-0.38	-350.35**
Pant Samrat x <i>S. gilo</i>	-0.86	-10.40**	-0.24*	-10.58**	-0.21	-63.47**
Pant Rituraj x PB-6	18.95**	1.24**	-1.63**	-0.96	0.11	-3.94
Pant Rituraj x Pusa Upkar	4.43*	3.00**	1.51**	4.47**	0.40	75.15**
Pant Rituraj x PB-101	4.85*	2.23**	-1.51**	0.79	0.02	161.09**
Pant Rituraj x <i>S. gilo</i>	3.26	-7.96**	-1.75**	-9.72**	-0.66	-164.85**
PB-6 x Pusa Upkar	5.31*	2.68**	-0.82**	2.20**	0.37	65.18**
PB-6 x PB-101	-13.79**	6.18**	-0.72**	2.49**	1.35**	373.47**
PB-6 x <i>S. gilo</i>	-11.52**	-7.82**	2.97**	-2.44**	-0.34	-91.12**
Pusa Upkar x PB-101	12.21**	1.43**	-0.37*	-2.81**	0.27	50.37**
Pusa Upkar x <i>S. gilo</i>	14.96**	-8.59**	-0.39*	0.23	-0.25	-66.78**
PB-101 x <i>S. gilo</i>	-15.29**	-8.96**	-1.19**	-2.33**	-0.93	-194.83**
S.E.(sij)	1.797	0.479	-1.11**	-1.21	0.057	11.539
S.E.(sij-sik)	2.659	0.709	-1.25**	-9.61**	0.085	17.074

*, **: Significant at 0.05 and 0.01 probability level, respectively.

Table 5: Estimates of sca for fifteen characters of eggplant for the year 2019

Crosses	Days to first flowering	Number of marketable fruits per plant	Number of unmarketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare(q)
SMB-115 x BARI	13.71**	2.71**	-0.67**	1.16	-0.22	-200.88**
SMB-115 x Pant Samrat	10.19**	-5.91**	3.41**	-2.12**	0.10	159.33**
SMB-115 x Pant Rituraj	0.19	-1.20*	-1.17**	-2.45**	1.11*	216.91**
SMB-115 x PB-6	2.49	0.17	0.07	0.08	-1.35*	-223.39**
SMB-115 x Pusa Upkar	-15.81**	-0.13	-1.80**	-1.57*	-0.12	-43.14*
SMB-115 x PB-101	13.32**	-1.39*	-1.33**	-2.20**	-0.20	-140.44**
SMB-115 x <i>S. gilo</i>	2.76	-8.62**	-1.23**	-9.72**	-0.54	-108.46**
BARI x Pant Samrat	-7.34**	12.66**	0.55**	13.12**	0.54	264.87**
BARI x Pant Rituraj	0.06	-3.51**	-1.21**	-5.16**	0.03	-35.89*
BARI x PB-6	18.51**	-1.97**	0.65**	2.77**	-0.20	13.89
BARI x Pusa Upkar	-13.00**	4.76**	-1.94**	2.30**	0.26	178.58**
BARI x PB-101	-14.58**	1.51**	1.53**	3.95**	0.55	120.08**
BARI x <i>S. gilo</i>	5.61*	-8.05**	-2.04**	-10.47**	-0.06	-32.01*
Pant Samrat x Pant Rituraj	-6.87**	-5.87**	0.54**	-4.88**	-0.03	-7.36
Pant Samrat x PB-6	-3.69*	-1.77**	-0.21	-3.37**	-0.76	102.01**

Pant Samrat x Pusa Upkar	-0.94	-0.50	-1.51**	-2.06**	-0.70	-203.25**
Pant Samrat x PB-101	13.30**	-2.25**	0.16	-2.88**	-0.34	-369.51**
Pant Samrat x <i>S. gilo</i>	-1.61	-11.14**	-0.52**	-11.10**	-0.34	-72.02**
Pant Rituraj x PB-6	18.43**	2.07**	-1.46**	0.52	-0.52	-32.22*
Pant Rituraj x Pusa Upkar	3.47	2.71**	1.68**	4.45**	-0.93	38.05*
Pant Rituraj x PB-101	6.22**	3.24**	-1.40**	2.00**	0.49	208.38**
Pant Rituraj x <i>S. gilo</i>	2.22	-8.01**	-1.76**	-9.58**	-0.77	-193.87**
PB-6 x Pusa Upkar	4.79*	1.28*	-1.09**	0.02	0.37	55.88**
PB-6 x PB-101	-10.34**	6.79**	0.00	5.64**	0.93	384.43**
PB-6 x <i>S. gilo</i>	-12.37**	-8.02**	-0.85**	-9.02**	-0.09	-96.98**
Pusa Upkar x PB-101	11.16**	2.02**	4.63**	6.84**	0.22	48.60**
Pusa Upkar x <i>S. gilo</i>	14.05**	-8.46**	-0.72*	-8.97**	-0.51	-63.75**
PB-101 x <i>S. gilo</i>	-15.90*	-8.95**	-1.25**	-9.93**	-0.99	-193.39**
S.E.(sij)	1.871	0.523	0.115	0.617	0.059	13.204
S.E.(sij-sik)	2.769	0.774	0.170	0.913	0.087	19.537

*,**: Significant at 0.05 and 0.01 probability level, respectively.

Table 7: Estimates of genetic components of variances for various characters of eggplant in diallel excluding reciprocal cross of eight parents for the year 2018

Parameters	Days to first flowering	Number of unmarketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare (q)
Variance due to gca (Vg)	14.92	2.09	17.50	0.32	15998.04
Variance due to sca (Vs)	129.03	3.52	86.83	0.65	31700.65
Ratio of variance due to gca and sca	0.12	0.59	0.20	0.48	0.50
Additive variance (VA)	107.59	7.89	33.00	0.47	25782.4
Non-additive variance (VD)	531.02	16.40	454.98	3.13	151522.9
gca/sca ratio	1.15	5.92	2.01	4.82	5.03
h ² Narrow Sense	19.79	37.73	9.28	12.04	13.35
h ² Broad Sense	91.72	99.34	98.90	98.87	99.16
Degree of dominance	2.22	1.44	3.71	2.58	2.42

Table 8: Estimates of genetic components of variances for various characters of eggplant in diallel excluding reciprocal cross of eight parents for the year 2019

Parameters	Days to first flowering	Number marketable fruits per plant	Number of unmarketable fruits per plant	Total number of fruits per plant	Total yield per plant (kg)	Yield per hectare (q)
Variance due to gca (Vg)	16.21	9.70	1.98	19.19	0.39	19082.30
Variance due to sca (Vs)	121.97	71.21	3.69	87.39	0.53	36288.79
Ratio of variance due to gca and sca	0.13	0.14	0.54	0.22	0.73	0.53
Additive variance (VA)	112.45	47.01	6.23	30.14	0.88	35781.5
Non-additive variance (VD)	499.02	374.03	16.94	458.84	2.39	173213.0
gca/sca ratio	1.33	1.36	5.37	2.19	7.25	5.25
h ² Narrow Sense	21.27	17.77	29.24	8.24	24.66	16.11
h ² Broad Sense	90.87	98.71	99.31	98.73	98.96	99.06
Degree of dominance	2.11	2.82	1.65	3.90	1.65	2.20

Discussion

Many vegetables still benefit from phenotypic selection of parents for quantitative features, especially in resource-constrained situations (Caguiat et al. 2014). Eggplant has a huge potential for using heterosis for yield and quality attributes, as well as biotic stress tolerance (Deshmukh et al. 2105). Furthermore, there is evidence that choosing parents that are genetically distant from each other might help create heterotic hybrids (Darrah et al. 1972).

A comprehensive diallel mating design permits the parents to be crossed in every imaginable combination, including selfs and reciprocals (Kaushik et al. 2018). The diallel is the most commonly used and misused mating design for acquiring genetic data (Hallauer et al. 2010). Furthermore, Johnson and King (1998) found that diallel mating designs are used to optimize selection differential and regulate coancestry in breeding populations. The significance of the mean squares owing to GCA, SCA, and GCA/SCA ratios is highlighted by the mean squares due to GCA, SCA, and GCA/SCA ratios. This also contributes in the development for future breeding programmes. In our research, we found that the SCA component had higher values than the GCA component, this suggested that physiological and vegetable features were mostly under non additive control, whereas yield per hectare was primarily under additive

genetic control (q). Furthermore, for the majority of characters in both years, the degree of dominance was greater than unity, indicating overdominance kinds of gene activity for these characters. The predominance of non-additive genetic variation suggested that heterosis breeding may be used to improve this feature in eggplant.

GCA's effects data gives a relative picture of which genotypes are relevant for selection and future breeding programme exploitation. Therefore, PB-101 x PB-6, BARI x Pant Samrat and BARI x Pusa Upkar all of which had high and substantial sca impacts for fruit output, were produced by average x good, good x good, and good x good general combiners, respectively. If a cross combination has high sca effects and per se performance, and at least one parent is a competent general combiner for a specific trait, it is hypothesized that such cross combinations would produce attractive transgressive segregants in subsequent generations. Two good general combiners, on the other hand, may not always produce good segregants. The crosses with higher estimations of sca had originated from good x good, good x average, good x poor, average x poor, and poor x poor general combiners. The better performance of hybrids containing average x bad general combiners revealed that gene activity was dominance x dominance (epistasis) reported by Jinks(1956). A hybrid like this might be used to create high-yielding homozygous lines (Darrah and Hallauer 1972). Summary table showing promising heterotic crosses with respect to each character in desired direction (Supplementary Table .2)

Conclusion

In the current study the presence of genetic variation in the form of heterozygous loci for specific characteristics may be linked to the crossovers where poor x poor and poor x good general combiners produce large sca effects in eggplant. Thus, ideal crosses would have strong sca effects, high heterosis or heterobeltiosis, at least one good general combiner parent, and good per se performance. PB-101, SMB-115, PB-6 and Pant Samrat were shown to be good general combiners for quantitative characteristics while PB-101, SMB-115, PB-6 and Pant Samrat were found to be strong general combiners for qualitative qualities based on combining ability. The hybrid (PB-101 x PB-6) of eggplant was found promising for commercial exploitation based on mean performance, heterosis, and combining ability.

Declarations

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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Tables

Table 1 is not available with this version.

Figures

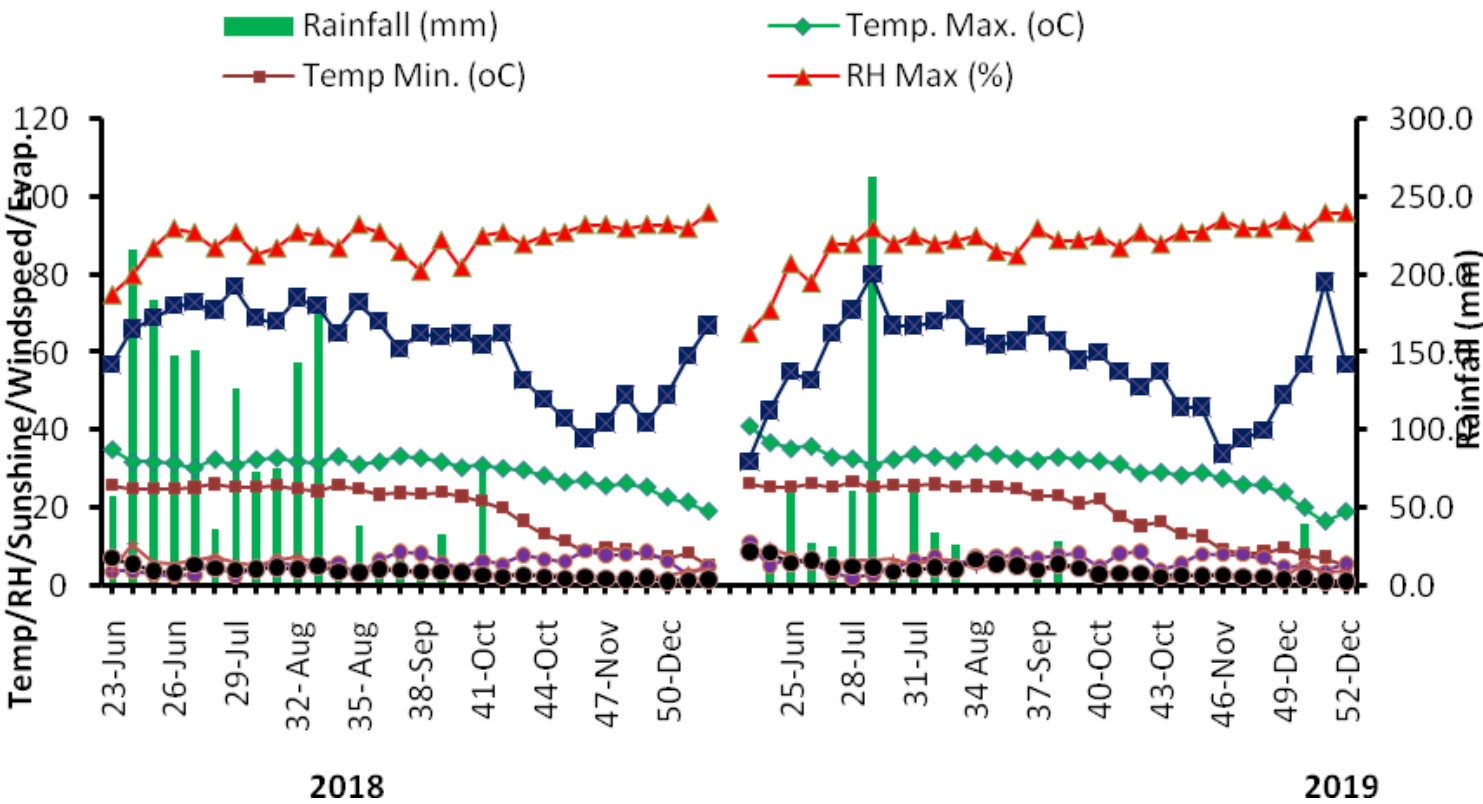


Figure 1

Graph showing monthly standard meteorological week’s average weather data of 2018 and 2019 at Vegetable Research Centre, G. B. Pant University of Agriculture & Technology, Pantnagar, India.

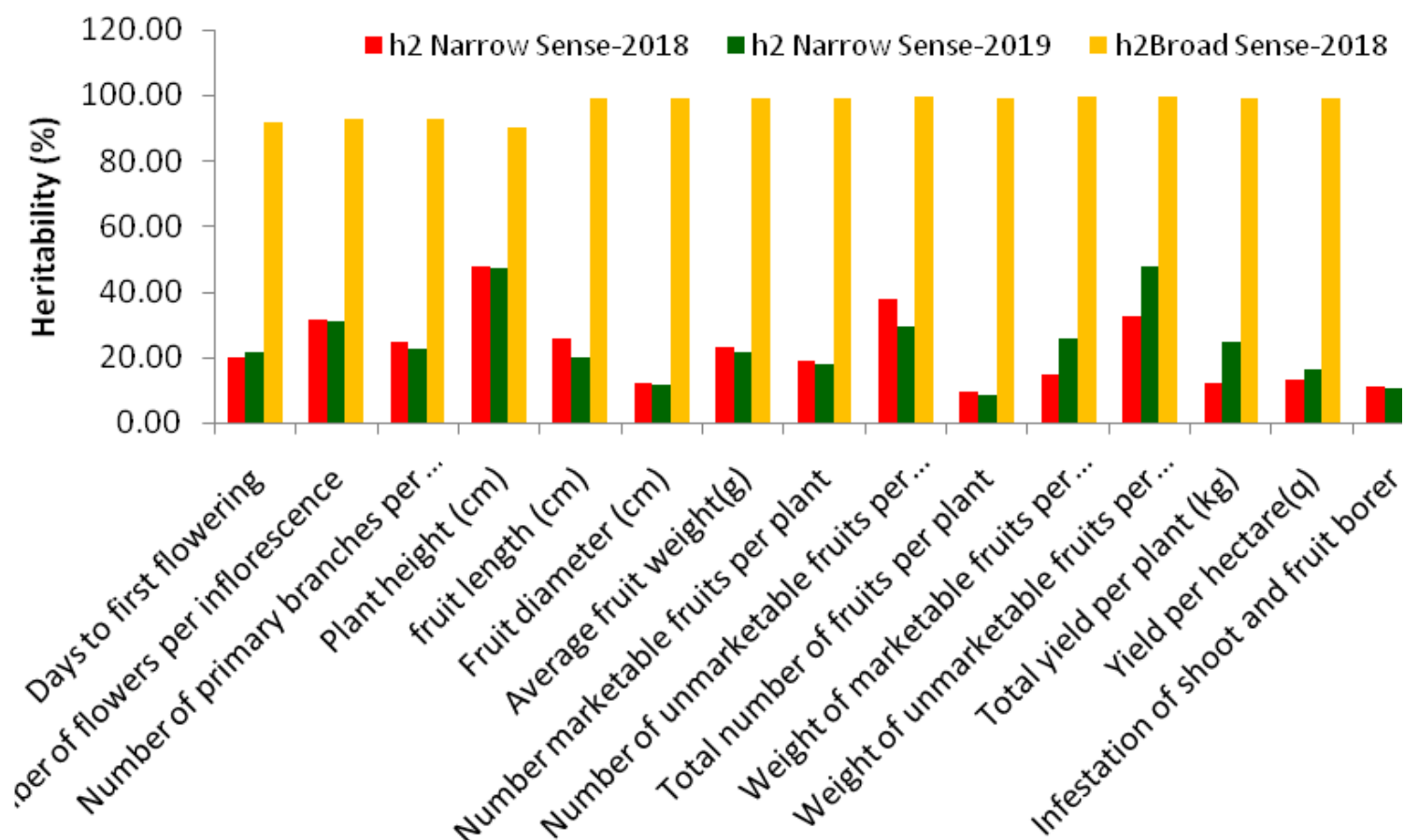


Figure 2

2, 3, 4 and 5 graphic representation are showing maximum and minimum range of heritability and GCA/SCA Ratio of both year for yield attributing characters in eggplant

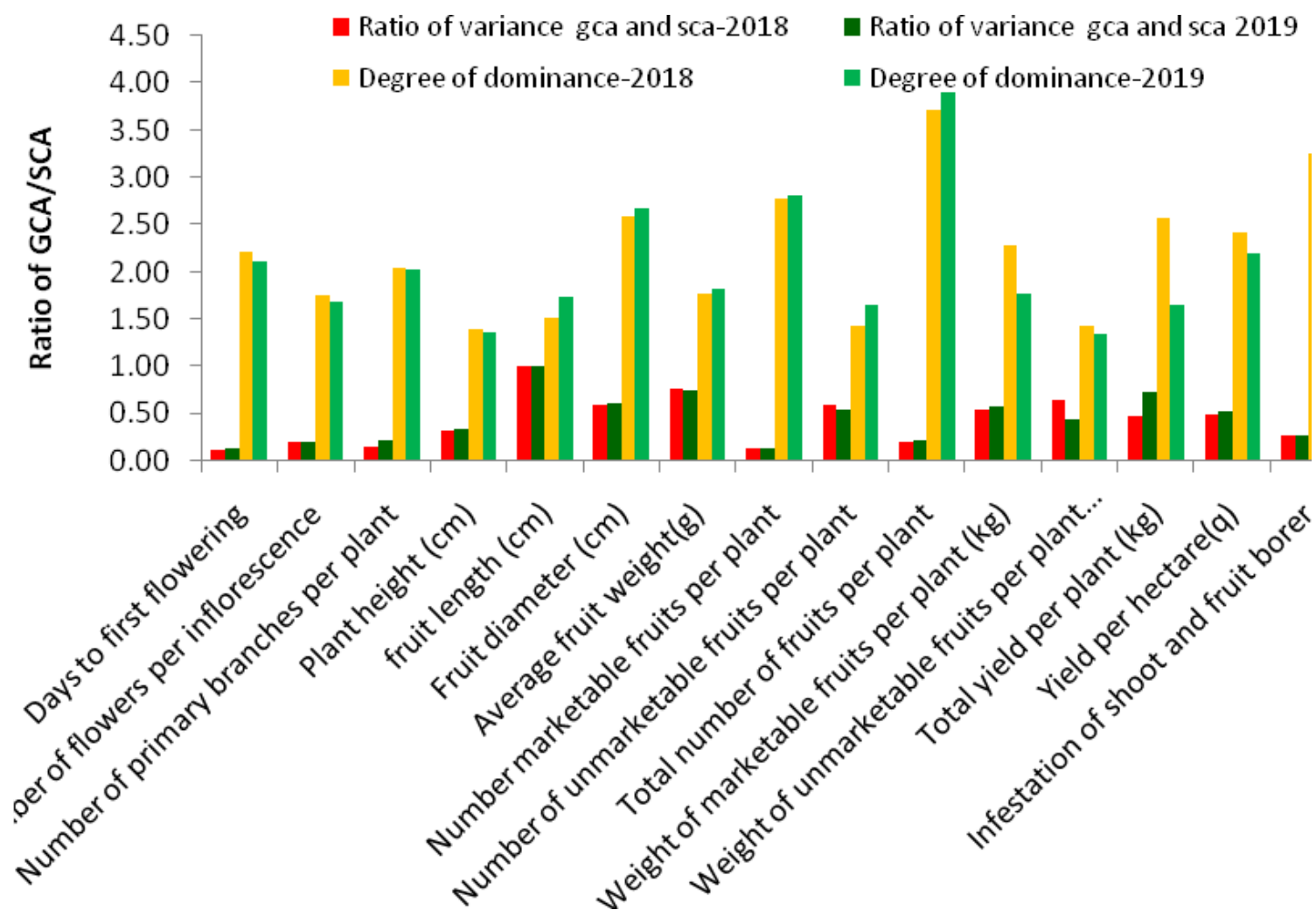


Figure 3

2, 3, 4 and 5 graphic representation are showing maximum and minimum range of heritability and GCA/SCA Ratio of both year for yield attributing characters in eggplant

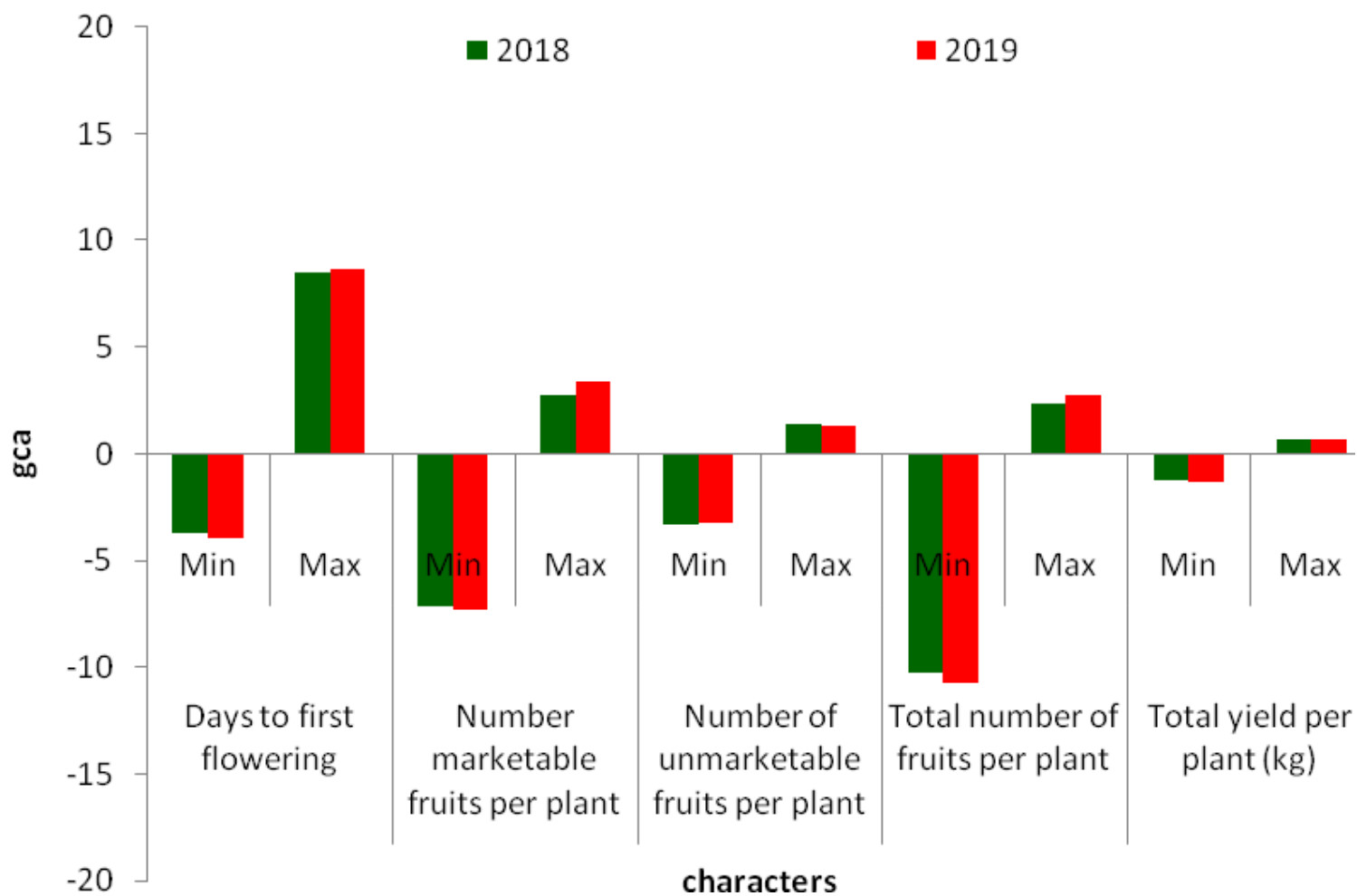


Figure 4

2, 3, 4 and 5 graphic representation are showing maximum and minimum range of heritability and GCA/SCA Ratio of both year for yield attributing characters in eggplant

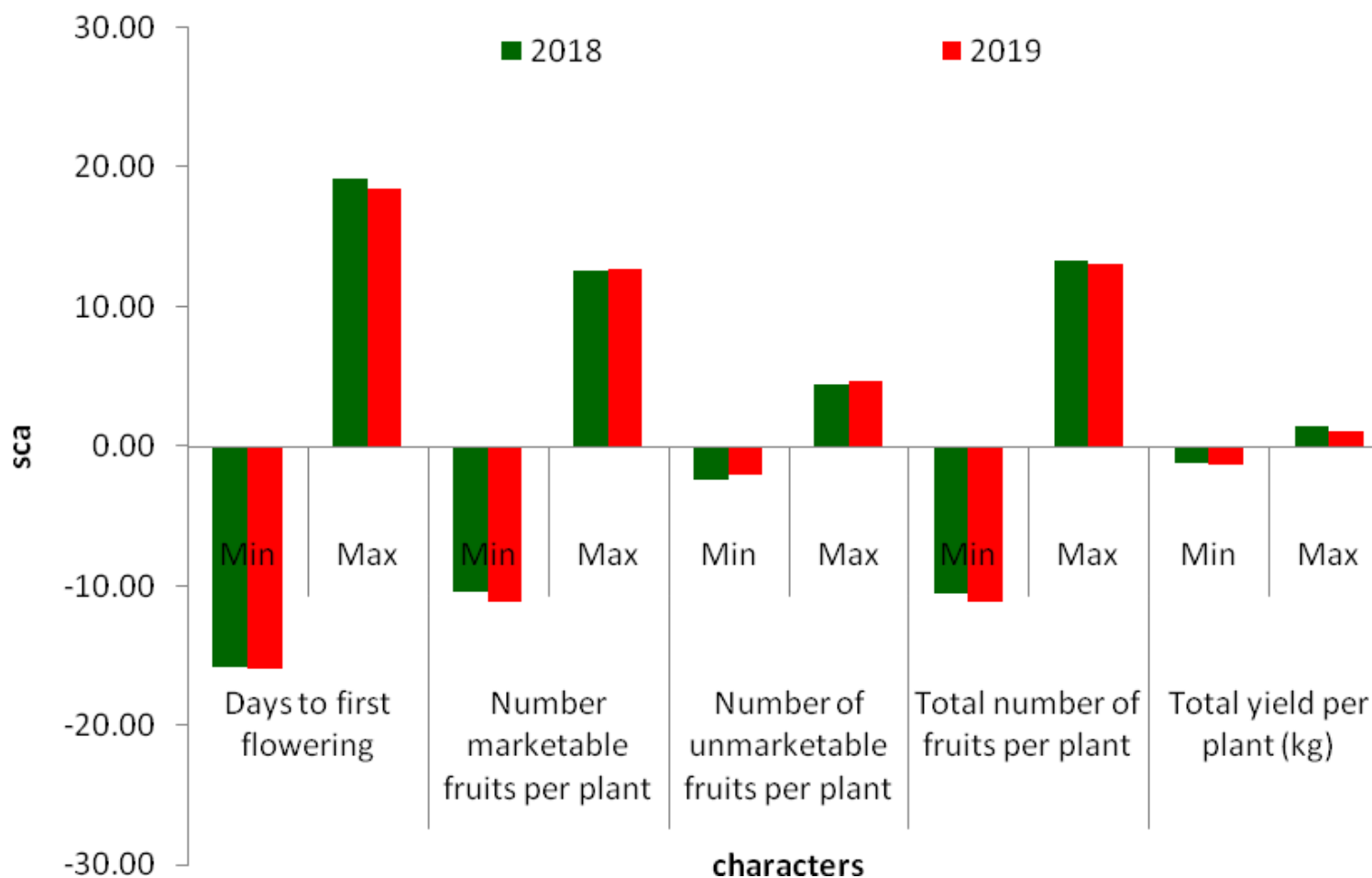


Figure 5

2, 3, 4 and 5 graphic representation are showing maximum and minimum range of heritability and GCA/SCA Ratio of both year for yield attributing characters in eggplant

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